

Harding Lawson Associates

REVISED FINAL
Phase I Treatability Study Work Plan
Perchlorate in Groundwater
Baldwin Park Operable Unit


Engineering and Environmental Services



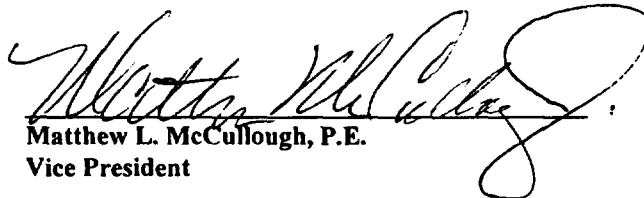
**REVISED FINAL
Phase I Treatability Study Work Plan
Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin**

**Prepared for
Baldwin Park Operable Unit Steering Committee**

HLA Project No. 37933 003



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November 7, 1997



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November 7, 1997

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Mr. Wayne Praskins
United States Environmental Protection Agency
Project Manager
75 Hawthorne Street
San Francisco, California 94105-3901

**Revised Final Phase I Treatability Study Work Plan, Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin**

Dear Mr. Praskins:

On behalf of the Baldwin Park Operable Unit Steering Committee (BPOUSC), Harding Lawson Associates (HLA) is submitting the attached "Revised Final Phase 1 Treatability Study Work Plan, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin". We have revised the Final Phase 1 Treatability Work Plan dated October 6, 1997 to address EPA comments provided in letters dated September 12, 1997 and October 16, 1997. We have also revised the Work Plan to reflect changes to the treatment plant configuration that were made during the design and construction stage of the project, and refined the description of startup, sampling, and analysis procedures.

The following are responses to your comments on the Work Plan. Each U.S. EPA comment is repeated below with citation to the page/column/section (e.g. 3/2/2.3) to which you referred. This comment is followed by the BPOUSC response.

Comment: *Please identify the "higher than normal level of quality control precautions" that will be taken.*
3/2/2.3

Response: Since the date that the Draft Work Plan was first issued, additional commercial laboratories have received approval for analysis of perchlorate in water. In addition the BPOUSC, in sampling BPOU monitoring wells, sent split samples to multiple laboratories. Results indicate precision in line with other analytical methods. Therefore the language present in the Draft Work Plan has been removed. Details on laboratory and field quality control procedures are now contained in the text of the Work Plan, Table 7.5, and Table 7.6.

Comment: *Please specify the perchlorate concentration or concentration range that is "representative of that anticipated in San Gabriel Basin."*
7/2/4.2

Response: Based on available water quality data, modeling performed to support extraction system design, and assumptions regarding the location, construction, and production of future extraction wells, the concentration of perchlorate in groundwater extracted by the BPOU project, is expected to range between 50 and 100 ug/L. The well at Aerojet's Sacramento facility which will provide treatment plant influent will contain approximately 50 ug/L perchlorate. This is stated in the text.

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Comment: *We understand that biological denitrification has been used directly on a drinking water system in France in a 5 MGD system, and indirectly on a drinking water supply in El Paso, Texas.*

Response: The workplan text has been modified to include reference to this information.

Comment: *Please specify the nitrate concentration or concentration range that is "similar to that expected in San Gabriel Basin."*

Response: Based on available water quality data, modeling performed to support extraction system design, and assumptions regarding the location, construction, and production of future extraction wells, the nitrate concentration in groundwater extracted by the BPOU project is expected to range between 20 and 25 µg/L. The well selected to provide treatment plant influent will contain between 50 and 70 mg/L nitrate. This is stated in the text. mg/L

Comment: *We expect that phase 2 testing can begin earlier than April 1998. As explained in the EPA letter dated 8/28/97, we expect that the Steering Committee will submit the following documents within 75 calendar days of EPA approval of the workplan: a written phase 1 progress report for treatability testing of the biological process that includes a description of and schedule for the remaining phase 1 testing and either: (i) a supplemental workplan for phase 2 treatability studies; or (ii) a detailed explanation why additional phase 1 testing is necessary before preparation of a phase 2 workplan and planned submittal date for the phase 2 workplan.*

We agree with the narrative on page 8 (Section 4.5) and page 13 (Section 10.0), but believe that tasks planned for completion after 11/27/97 can be finished and submitted earlier. Specifically, we believe that in the absence of unforeseen difficulties during pilot-scale testing, "Phase 1 testing" can be completed before 12/27/97. We also believe that "Draft Phase 1 Report" can be submitted well before 2/25/98. The proposed schedule allows an unnecessarily lengthy 6 1/2 weeks after the end of testing for report preparation.

We assume that the last two dates provided in Section 10.0 are in 1998, not 1997.

Response: The BPOUSC will comply with the project reporting requirement presented in EPA's letter dated August 28, 1997. The text of Section 10.0 has been modified accordingly.

Although U.S. EPA has communicated in writing (October 16, 1997) and orally (October 22, 1997) the belief that Phase 1 testing can be completed before 12/27/97, and that a draft Phase 1 report can be prepared before 2/25/97, the U.S. EPA and the BPOUSC agreed in a meeting on October 22, 1997 that following receipt of the November 27, 1997 written progress report both parties would review progress made and revise the schedule accordingly. The BPOUSC will certainly work diligently to accomplish tasks as rapidly as possible, and look for ways to reduce the schedule for report preparation.

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The last two dates in Section 10.0 were incorrectly reported as 1997 and have been revised to 1998.

Comment:
8/2/4.5

One of the objectives listed for phase 2 is to evaluate the relative bacterial preference for perchlorate and nitrate. The treatability study should examine other parameters relevant to microbially-catalyzed oxidation-reduction reactions, including the presence and depletion of competing electron acceptors. Measurement of these parameters may provide information that can be used to optimize removal rates, reduce operating costs, and diagnose the cause of lower than expected perchlorate removal rates. These processes are commonly examined during evaluations of biological degradation and natural attenuation in groundwater (e.g., see Technical Protocol for Natural Attenuation of Chlorinated Solvents in Groundwater, by T.H. Wiedemeier et. Al.).

Parameters commonly measured during studies of biological degradation and natural attenuation include:

- *iron II (Fe^{+2}) - reaction product for competing redox reaction (iron reduction)*
- *sulfate and sulfide - competing electron acceptor and reaction product (sulfate reduction)*
- *methane - reaction product for competing redox reaction (methanogenesis)*
- *oxidation-reduction potential - indicator of type of redox reactions that may occur.*

Consideration should also be given to measurement of additional chlorine compounds, and preparation of a mass balance of all chlorine species, in order to determine whether the perchlorate is fully reduced to chloride. Other possible chlorinated products include chlorate, chlorite, and hypochlorite.

Text and Tables in revised workplan include measurement or analysis of sulfate, redox potential, chlorate, chlorite, and hypochlorite. Sulfide is not mentioned in the text, but included in Tables 7.1 and 7.3. Fe^{+2} and methane are not mentioned in the text or Tables.

Response:

The BPOUSC will examine the presence and effect of competing electron acceptors in Phase 2 treatability testing. To the extent possible data to support this evaluation will be collected and interpreted during Phase 1 treatability testing. Specifically redox potential and dissolved oxygen will be measured in the field and on select samples perchlorate/chlorate/chlorite/hypochlorite/chloride, sulfate/sulfide, and nitrate/nitrite will be measured. These parameters will be measured during the initial start up period and the performance monitoring period in accordance with Tables 7.1, 7.2, and 7.3.

Iron (II) and methane will not be measured during Phase 1 testing. Concentrations of iron in groundwater in both Sacramento and San Gabriel Basin are expected to be low. Analysis for iron (II) is most commonly performed using a colorimetric field technique with a high reporting limit. Therefore iron (II) concentrations will likely be less than this

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reporting limit. Should metals analysis performed during the initial source water analysis result in total iron concentrations that suggest iron (II) would be measurable, analysis for iron (II) will be reconsidered.

Samples for the analysis of methane will not be collected because based on the slightly reducing (anoxic) conditions observed during past pilot-scale testing measurable concentrations of methane are not expected. In addition it will not be possible to collect a meaningful and representative sample from the GAC/FB bioreactor which is not a pressurized system and is open to the atmosphere.

Throughout the treatability study, analytical test results will be evaluated to determine whether they are providing meaningful information. Tests that are providing meaningful information will be continued; however, some analytical testing may be discontinued if these tests are not providing meaningful data.

Comment: *The photograph of the pilot unit shows an air compressor, oxygen generator, bubble contactor, and dissolved oxygen control meter. Presumably, these will not be used during the treatability study.*

Response: The photograph of the pilot unit was provided by the vendor. This photograph includes system components that may or may not be used in this pilot study. Specifically the GAC/FB bioreactor will not contain an air compressor, oxygen generator, or bubble contactor. In line meters, placed in the bioreactor influent and effluent lines will measure dissolved oxygen, pH, redox potential, and temperature.

Comment: *The Process and Instrumentation Diagram also shows an Oxygen Generation System and recycling line. Please correct the diagram or explain the need for this equipment. Also, please add other system components described elsewhere in the workplan (e.g., air stripper, filters, effluent pumps, recycle line, backwash line, backwash pumps, effluent equalization tank, 20,000 gallon storage tank, sample ports).*

Please provide a schematic showing the relationship between major system components. Describe the purpose of any components not discussed in the text. If preferred, provide as separate document.

Response: The Process and Instrumentation Diagram (P&ID) for the pilot unit is a general P&ID and was provided by the vendor. This P&ID includes system components that may or may not be used in this pilot study.

A schematic showing major system components is not provided in the Work Plan. This request will be addressed by Aerojet in a separate letter.

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Comments: *Should tests also be conducted in reverse order: through the biological unit first, followed by air stripping? Isn't the biological process likely to remove some of the VOCs, offering the potential to reduce air stripping and/or offgas control costs?*
8/2/5.0

Response: Under our current schedule, we do not anticipate any time will be available to reverse the order of unit operations. The current system configuration was selected because we wished to focus solely on perchlorate and nitrate treatment and because of a concern that flow of water containing VOCs through the bioreactor would remove some VOCs but that others would be recalcitrant, and that vinyl chloride, a VOC that is not captured effectively by vapor phase carbon, may be formed. At the conclusion of our planned testing, we will evaluate and prioritize what further testing is necessary. This has been addressed in the Work Plan in Sections 5.0 and 10.0.

Comment: *Will the methanol in denatured alcohol limit the end use of the water? Should methanol be analyzed for in the effluent?*
9/2/5.0

Water temperature should be measured, given the potential temperature dependence of reaction rate. If the water temperature in the reactor may be cooler than San Gabriel basin groundwater (as implied by need for heat tracing on the filtration line), should water temperature be adjusted?

The text describes the effluent being discharged into a 550 gallon equalization tank. Is this tank for solids removal?

Figure 5-2 shows an equalization separation tank on the influent line. What is the purpose of this tank?

"Alcohol" specified as carbon source/electron donor in revised workplan. Possible impact of methanol not discussed.

Need for water temperature adjustment not discussed.

Purpose of equalization tanks (2) not discussed.

Response: Treated water will ultimately have to be acceptable for potable use. Based on past treatability studies neither methanol or ethanol are expected in the effluent. This is in fact a goal of the treatability study, to minimize alcohol addition so that perchlorate reduction is maximized but residual substrate (alcohol) and nutrients are minimized. To ensure this goal is achieved water quality analysis for ethanol and methanol will be performed as described in Section 7.0. Analytical reporting limits for these chemicals and all other chemicals of concern, as shown in Table 7.4, are below available health based standards for water intended for potable use.

As described in Section 7.1 water temperature will be measured during treatability testing; however, no adjustment in water temperature is planned. We anticipate that

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10/10/97*

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extracted groundwater temperature will be fairly constant based upon previous test data. Some precautions will be taken to ensure that cold weather does not affect system operations. These precautions are described in Section 5.0. During previous treatability testing of this technology, performed from April through December, water temperature varied less than 2 degrees centigrade. With respect to comparison between Sacramento and San Gabriel Basin, groundwater temperature in Sacramento generally varies between 18 to 22 degrees centigrade averaging approximately 20 degrees, while the temperature of groundwater in San Gabriel Basin generally varies from 10 to 28 degrees centigrade averaging approximately 22 degrees.

Based on changes made to system configuration during design and construction activities the equalization tank on the influent line has been eliminated. There is a 70 gallon reservoir in the base of the air stripper that with appropriate sensors will serve to assure a constant flow rate to the fluidized bed.

The 500 gallon effluent equalization tank will be used to assure a constant flow through the pump which sends treated water back to the GET-B system. Contrary to previous discussions, the GAC/FB bioreactor has an internal recycle system and the equalization tank is therefore not needed for this purpose. The text of Section 5.0 has been revised to reflect these changes and provide additional clarification.

Comment: *Should the expected organic loading rate reflect the difference in perchlorate concentration between Sacramento and Baldwin Park?*
10/2/6.1

The workplan states that "targeted analytical parameters will be measured after each change of operating conditions." How long is needed for stabilization - minutes or hours? Perhaps a parameter vs. Time curve should be generated to determine the optimal time for sample collection after a change in operational conditions.

Response: The extraction well selected as the source water will yield water with perchlorate and nitrate concentrations similar to that expected in San Gabriel Basin (Sections 4.2 and 4.3). The organic substrate will be initially added to the influent at a rate that was recommended as a result of previous treatability testing. This was a recommendation for addition of alcohol to perchlorate at a molar ratio of 4:1. The expected perchlorate concentrations will be significantly lower than encountered during previous testing and nitrate concentrations are expected to be significantly higher than encountered during previous testing. Therefore the initial alcohol loading rate will be set at a ratio of 4:1 based molar concentrations of perchlorate plus nitrate.

Reactor stability will be investigated as part of the treatability study. Although it is expected that the reactor will respond relatively rapidly to changes in operating conditions, approximately 24 hours will be allowed for stabilization after an influent change. At this time samples will be collected and analyzed and data interpreted before

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additional operating parameters are changed. This approach is described in the workplan in Sections 6.1 and 7.2. These data will allow plots of parameter vs. time.

Comment: *The workplan states that DO concentrations in the influent and effluent of the GAC/FB system will be monitored daily. We assume that these measurements will be made at sample ports located on the influent and effluent lines immediately adjacent to the reactor vessel. Please show the locations of the recycle line and sample ports on Figure 5-2.*
11/1/7.1

Project-specific schematic not provided.

Response: The Process and Instrumentation Diagram (P&ID) for the pilot unit, as shown in Figure 5-2, was provided by the vendor. This P&ID includes system components that may or may not be used in this pilot study and does not detail sample port locations. During bioreactor construction sampling valves that withdraw water from the influent and effluent lines will be added and sampling devices that withdraw water from positions that are approximately 25 %, 50 %, and 75 % through the reactor flow path will be added.

A project specific schematic is not provided in the Work Plan. This request will be addressed by Aerojet in a separate letter.

Comment: *The source water for the treatability testing should be sampled for anions, metals, general water chemistry, and other parameters that might affect system performance.*
11/2/7.2

Why collect the effluent ethanol samples as composites rather than grab samples?

Analysis of source water not specifically addressed. Will "GAC/FB influent" be identical to source water ?

Comments requesting explanation for collection of composite samples not addressed.

Response: The influent and effluent will be tested for a wide range of water quality parameters including appropriate parameters from the California Code of Regulations (CCR), Title 22, common cations, common anions, and metals. At least one sample of influent (source water) will be collected and analyzed during the initial system startup. In addition weekly samples of influent and effluent will be collected and tested for the duration of the performance monitoring period.

All samples will be gathered as grab samples. In the Draft Work Plan the only composite samples to be collected were from the effluent equalization tank, with all other samples collected as grabs. The rationale for collecting composite samples from this tank was to obtain an integrated composition of this water prior to discharge to the ground surface. Now that treated water is to be discharged directly to the GET-B treatment system these composite samples will not be needed. The text of Section 7.2 has been revised accordingly.

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Comment: *The list of analytes should include parameters mentioned in the comment on page 8, column 2, section 4.5.*
12/1/7.3

See earlier comment.

Response: Section 7.0 and associated tables have been modified in accordance with this comment.

Comment: *The schedule should be modified as explained in the comment on page 8, column 1, section 4.5.*
12/2/10.0

See earlier comment.

Response: The schedule as described in Section 10.0 has been modified in accordance with this comment.

Comment: *How likely is it that an additional treatment step will be needed to remove residual alcohol ?*
8/2/5.0

Response: Past treatability testing using this technology produced effluent that did not contain detectable concentrations of alcohol. It is the objective of this testing to optimize reactor performance such that effluent does not contain measurable alcohol. The detection limits for these and other parameters as shown on Table 7.3 are below health based concentrations suitable for unrestricted consumption (potable).

Comment: *Why is filtration no longer believed to be needed ?*
9/2/5.0

Why does the workplan no longer specify a 20,000 gallon backup tank for discharge of effluent, or a recycle line ?

Response: Filtration is no longer needed as effluent from the treatment system will be discharged to the GET-B treatment system. Testing and selection of a suitable filtration system will be performed during Phase 2 treatability testing.

The 20,000 gallon tank is no longer needed. Effluent was to be retained in this tank and tested prior to discharge to the ground surface. Now effluent will be pumped directly to the GET-B treatment system, and therefore storage capacity is not needed.

Comment: *The text states that approximately 5 % of all samples will be collected as splits. How will these samples be chosen ? Will these analyses be in addition to the duplicates listed in Table 7.2 ?*
10/2/6.3

The text also states that field blanks, equipment blanks, and trip blanks will be submitted daily or weekly. Is this correct?

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Response: The duplicate samples previously shown on Table 7.2 are the split samples that will be collected at a minimum frequency of 5 %. To clarify this issue field quality control samples are now shown separately in Table 7.5.

The text has been revised to state that field quality control samples that will be collected will include sample splits (duplicates), and trip blanks. Field blanks and equipment blanks are not appropriate for this treatability test and have therefore been deleted.

Comment: *Please describe the process for obtaining Regional Water Quality Control Board approval for discharge of treated water.*
12/1/8.0

Response: Effluent from this treatability test will be pumped to the GET-B. Therefore additional discharge approval specifically for this treatability test is unnecessary. Earlier drafts of the Work Plan planned for discharge to the ground surface, but this protocol was modified with the knowledge of the Regional Water Quality Control Board.

Comment: *Did DHS or MWD review the workplan, as described in the schedule ?*
13/1/10.0

Response: Both DHS and MWD were sent a copy of the Work Plan , but to date no comments have been received.

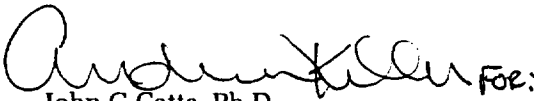
Comment: *The MDL for perchlorate appears to be incorrectly reported as 28 ug/L.*
Table 7.3


Response: Both the Method Detection Limit and the Reporting Limit for perchlorate were incorrectly reported in Table 7.4. This table has been revised.

Should you have questions regarding this Work Plan or the treatability testing that is in progress, please do not hesitate to call Don Vanderkar at (916) 355-4282, John Catts at (415) 899-8825, or Matt McCullough at (714) 260-1800.

Sincerely,

HARDING LAWSON ASSOCIATES


John G. Catts, Ph.D.
Chief Technical Officer


Matthew McCullough P.E.
Vice President

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1.0 INTRODUCTION

For the past several years the Baldwin Park Operable Unit Steering Committee (BPOUSC), the U.S. EPA Region IX (U.S. EPA), Three Valleys Municipal Water District (TVMWD), and the Metropolitan Water District of Southern California (MWD) have been planning a combined groundwater remediation and water supply project in the San Gabriel Basin, California. Project planning was initiated in response to a requirement of U.S. EPA to remediate a plume of volatile organic compounds (VOCs) in groundwater in the Cities of Azusa and Baldwin Park. This plume is distributed from locations north of Interstate 210 in the City of Azusa southwest to locations in the vicinity of Interstate 10 in the City of Baldwin Park. This area is called the Baldwin Park Operable Unit (BPOU).

The BPOUSC was in the process of negotiating agreements for the project with the U.S. EPA, MWD, and TVMWD when in June 1997 concentrations of perchlorate ion, above the State of California Department of Health Services (DHS) provisional action level of $18 \mu\text{g/L}$, were found in BPOU groundwater. Before the project can move forward, the potential impact that perchlorate has on the conceptual project design must be evaluated. Perchlorate in BPOU groundwater is particularly troublesome since there is no treatment technology that has been demonstrated to be effective in reducing concentrations of perchlorate to the provisional action level.

Treatability testing at a pilot-scale has been successfully performed at the Aerojet General Corporation (Aerojet) facility near Sacramento, California. The technology can be described as a biochemical reduction process using a fixed film bioreactor. The fixed film is attached to granular activated carbon operated as a fluidized bed (GAC/FB). This pilot-scale test demonstrated that the technology was effective in treating perchlorate in groundwater.

There are however several important differences between objectives of this previous pilot-scale work and current objectives for the BPOU project. First, the flow rate was 0.1% of that needed in San Gabriel Basin. Second, the influent perchlorate concentration was over 100 times that expected in San Gabriel Basin. Third, the pilot

system was not designed to achieve nor did it achieve effluent perchlorate concentrations less than $18 \mu\text{g/L}$ provisional action level. Finally, the previous testing was not designed to deliver potable water.

The purpose of this Work Plan is to describe the approach and methods that will be used in performing pilot-scale treatability testing of the GAC/FB biochemical reduction technology specifically for application in San Gabriel Basin. The pilot-scale testing will be performed in two phases. In the first phase the objective is to assess if the chosen technology can achieve the target effluent goal. In the second phase, scientific and engineering data needed to design and construct a full-scale treatment system will be collected.

Although this GAC/FB treatment technology has shown the potential to treat perchlorate at concentrations present in San Gabriel groundwater, other treatment technologies may also be applicable. The BPOUSC is in the process of completing a technology screening to assess the viability of other treatment technologies and make recommendations regarding bench-scale and pilot-scale testing if appropriate.

2.0 HISTORY OF PERCHLORATE ISSUES

In February 1997 perchlorate was discovered in five drinking water supply wells in Sacramento, California. This discovery was a result of the recent improvement in the method of perchlorate analysis which has only allowed detection of perchlorate in water at concentrations below the level which EPA and DHS considers acceptable for use by the public ($18 \mu\text{g/L}$) since early 1997. The detection of perchlorate in Sacramento water supply wells led DHS to perform sampling and analysis of groundwater for perchlorate in other portions of the state including San Gabriel Basin.

2.1 Distribution of Perchlorate in the BPOU

Perchlorate was first detected in San Gabriel Basin groundwater in June 1997 by DHS. This prompted the Main San Gabriel Basin Watermaster (MSGBWM) and the BPOUSC to perform additional groundwater sampling and

analysis to better understand the distribution of perchlorate in groundwater.

To date, the BPOUSC has compiled perchlorate data for over 50 monitoring wells, production wells, and sampling points in the vicinity of the BPOU. Perchlorate analysis for production wells was performed on samples obtained by the DHS and MSGBWM and provided by the San Gabriel Basin Water Quality Authority (SGBWQA). Groundwater samples from monitoring wells in the BPOU were collected by Camp Dresser McKee, Harding Lawson Associates, and Geosyntec on behalf of the BPOUSC.

The lateral and vertical distribution of perchlorate in groundwater has been previously described (see "The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin" [HLA, 1997a], "Final Addendum to Sampling and Analysis Plan, Pre-remedial Design Groundwater Monitoring Program, Baldwin Park Operable Unit, San Gabriel Basin" [HLA, 1997b]). In general, the area which contains concentrations greater than the DHS provisional action level of 18 $\mu\text{g/L}$ is 5 to 6 miles in length, oriented from northeast to southwest, approximately 1 mile in width, and up to 800 feet in depth. This approximate perchlorate distribution is based on maximum concentrations detected in any sample or at any depth within a given well.

It should be noted that for the majority of these wells, only a single sample has been collected. In addition, there is uncertainty regarding the concentrations above the 18 $\mu\text{g/L}$ provisional action level in both the northernmost and southernmost portions of the plume. Therefore, the known distribution may change as wells are resampled or new wells constructed and sampled.

2.2 Toxicity/Provisional Action Level

A significant source of uncertainty associated with the potential effect that concentrations of perchlorate ion in groundwater may have on the selection of a remedy for the BPOU is the limited data available on the toxicity of low concentrations of perchlorate to humans. Limited animal studies have been performed and no studies documenting human effects at low concentrations are available. Therefore, the

provisional Reference Dose (RfD) and provisional action level established by DHS have an inherently high level of uncertainty. These may be subject to significant change once appropriate studies have been conducted.

The primary human health concern related to perchlorate is that it interferes with the thyroid gland's ability to utilize iodine to produce thyroid hormones. While high doses of perchlorate (mg/kg per day levels) have been used therapeutically in medicine, no studies have examined the health effects at the lower dosages potentially received from the ingestion of groundwater at concentrations present in the San Gabriel Basin groundwater. Examples of therapeutic perchlorate use are as a medicine to treat Grave's disease, a condition in which excessive amounts of thyroid hormone are produced, and in Europe to counteract the side effects of the heart drug amiodarone.

In December of 1992, the U.S. EPA National Center for Environmental Assessment (NCEA) responded to a request by U.S. EPA Region IX to evaluate the toxicity of perchlorate in soil and groundwater. Based on limited data on the toxicity of this ion, NCEA recommended a provisional RfD for soil and groundwater that included a conservative safety factor and correlated with acceptable levels of 70 mg/L and 3.5 $\mu\text{g/L}$, for these media, respectively. NCEA later stated in a letter dated February 25, 1997, that these provisional RfDs were merely opinions provided to EPA regional officials and were not to be considered formal EPA policy.

In April of 1993, the Perchlorate Study Group (PSG) was formed by the U.S. Air Force, various aerospace companies, and the two primary manufacturers of perchlorate compounds. The mission of the PSG was to review and evaluate information on the toxicity of perchlorate and develop better information on what constitutes an acceptable level of perchlorate in soil and groundwater.

In June 1995, the PSG submitted a position paper to the U.S. EPA presenting the groups' findings. The U.S. EPA again reviewed available toxicological data on perchlorate and concluded that although information was available on the effects of high concentrations of perchlorate on the thyroid, there was not enough information on the effects of long-term exposure to low

concentrations. In October 1995, the U.S. EPA responded to the PSG paper by recommending a provisional reference dose correlating to an acceptable level in groundwater that ranged between 3.5 and 17.5 $\mu\text{g/L}$. Because there was limited information available, the U.S. EPA recommendation includes a large margin of safety. In fact a 300-fold margin of safety above the level at which no health effects were observed was used to establish the 17.5 $\mu\text{g/L}$ provisional standard. This value became the 18 $\mu\text{g/L}$ value currently used as the DHS provisional action level.

In March 1997, the PSG assembled a technical Peer Review Panel of nationally recognized scientists to evaluate the health effect of perchlorate in drinking water. The conclusion of this panel was that there are insufficient toxicological data available to establish a technically defensible RfD or support the U.S. EPA provisional RfD.

In May 1997, the Air Force and the PSG brought the Peer Review Panel back together with California state and federal regulators in Cincinnati, Ohio. The purpose was to have the panel develop a protocol and the scope of studies that would lead to a recommendation to U.S. EPA for a new RfD which could serve as the basis for a groundwater MCL. The Air Force and the PSG have undertaken to commence the necessary studies in August 1997, interpret the data, peer-review the results, and submit recommendations to U.S. EPA by July 1998.

It should be noted that to date the U.S. EPA has not endorsed the Peer Review Panel but did have representatives participate on the panel. Further, U.S. EPA has not endorsed the evaluation process or committed to a schedule for review of the resultant recommendations or its effect on the U.S. EPA's former provisional RfD. As a result it is uncertain how long it will take for the provisional RfD to be revised and an MCL established.

In February 1997 the DHS set a provisional action level for perchlorate in groundwater at 4 $\mu\text{g/L}$, but at that time laboratory methods were not designed or approved to measure concentrations this low. In May of 1997 DHS, based on the results of U.S. EPA's recommendations, revised its provisional action level from 4 $\mu\text{g/L}$ to 18 $\mu\text{g/L}$. DHS stated that it had reevaluated scientific

studies in greater detail and had determined that 18 $\mu\text{g/L}$ is consistent with the range of perchlorate exposures the U.S. EPA considers protective of human health. DHS requires that water suppliers promptly notify customers whenever perchlorate is present in concentrations greater than 18 $\mu\text{g/L}$.

2.3 Analytical Methodology and Detection Limits

At the time that the U.S. EPA set its provisional RfD and the DHS set its provisional action level for perchlorate in groundwater, no EPA laboratory method existed and few laboratories were set up to analyze for perchlorate. Some laboratories were using a modification of EPA Method 300 (Ion Chromatography), while others were using an Ion Selective Electrode (ISE). Reporting limits for analysis of perchlorate in water were generally in the range of 400 to 1,000 $\mu\text{g/L}$.

It was not until April 1997, that the DHS (Sanitation and Radiation Laboratories Branch) attained the current reporting limit of 4 $\mu\text{g/L}$ after having performed its own method development. To date, this method has not been peer reviewed. Because perchlorate is not a regulated substance DHS does not issue laboratory certification for method analysis. DHS will however issue informal approval to perform perchlorate analysis once a laboratory meets DHS requirements.

To receive DHS approval the laboratory must hold a current certification for EPA Method 300, develop a Standard Operating Procedure (SOP), determine its Method Detection Limit (MDL), and prepare a data package demonstrating its ability to perform the analysis. The laboratory must then contact the DHS who will send out a field auditor. The laboratory must perform analysis on the samples with acceptable results ($\pm 10\%$) in the presence of the auditor. To date, at least six laboratories in California have received approval.

3.0 PREVIOUS PERCHLORATE TREATABILITY REVIEW

In response to the presence of perchlorate in groundwater at Aerojet's Sacramento facility, a considerable amount of work has been performed to address perchlorate treatability. This work, consisting of technology screening, bench-scale studies, pilot-scale studies, and the design of a

full-scale (1,500 gpm) system, was performed by Aerojet and a consultant starting in 1994.

3.1 Literature Review

In 1994, Aerojet completed an initial screening of technologies available for treatment of perchlorate. An on-line data search was first performed. The following databases were searched:

- Energy SciTech (1974-1994)
- Ei Compendex Plus (TM) (1970-1994)
- National Technical Information Service (1964-1994)
- Aerospace Database (1962-1994)
- Chemical Engineering Abstracts (1970-1994)
- Biotechnology Abstracts (1970-1994)
- PTS Aerospace/Defense Markets (1986-1994)
- Pollution Abstracts (1970-1994)
- Analytical Abstracts (1980-1994)

Only limited information on the treatment of water for perchlorate was found, and the available data addressed the treatment of high concentration wastewaters, not low concentrations in groundwater. The technologies for which information was found include both biological and physical/chemical treatment methods.

Biological Methods

Biochemical reduction of oxygen-containing compounds, like perchlorate, with the simultaneous biochemical oxidation of organic matter contained in sludge from municipal wastewater treatment plants was the subject of three patents with dates from 1973 to 1994. The patents varied in bioreactor configuration and the source and type of the microorganisms used. Concentrations in wastewater in excess of 7,000 mg/L were the subject of treatment.

A 1973 patent (Yakevlev et al., 1973) describes biochemical oxidation of activated sludge in an

un-aerated tank. A 1976 patent (Korenkov et al., 1976) is a modification of this approach but a specific microorganism is identified. The source of the microorganism is settled municipal sewage. A 1994 patent (Attaway et al., 1994) held by the U.S. Air Force uses an anaerobic bioreactor and a specific microorganism. Brewer's yeast, cottonseed protein, and whey powder were all added to the bioreactor.

Physical/Chemical Methods

The physical/chemical processes which were reviewed by Aerojet in 1994 included ion exchange, reverse osmosis, an electrochemical process which reduces inorganic oxyhalides, and a process where perchlorate wastewater was treated with an oxidant in supercritical (high temperature, high pressure) water.

The electrochemical method, patented in 1992 (Kaczur et al., 1992), uses an anode and cathode separated by a cation exchange membrane. A 1993 paper (Harradine et al., 1993) describes treatment of perchlorate in wastewater with an oxidant (O_2 , air, H_2O_2) under conditions of high pressure (200 atm) and temperature (370°C).

In addition to these two techniques, Aerojet's staff reviewed the applicability of ion exchange and reverse osmosis treatment technologies. Although both ion exchange and reverse osmosis are considered technically proven methods for reducing concentrations of dissolved solids in waters, there are significant technical challenges presented by both methods for treatment of water containing perchlorate.

With respect to ion exchange, common groundwater ions will interfere with perchlorate adsorption. The ion exchange resin is regenerated with brine (usually sodium chloride). Perchlorate concentrations in regeneration brine present a unique disposal or treatment problem.

There are significant operational difficulties associated with the use of reverse osmosis. Like ion exchange, perchlorate is not treated but merely conveyed to a waste concentrate that would be a waste disposal challenge. The resultant brine would contain perchlorate and would be significant in volume. In addition, pretreatment of influent, use of anti-fouling

chemicals, and membrane cleaning are time-consuming and costly.

Based on the literature review described above, Aerojet decided to pursue laboratory-scale testing of chemical reduction and biochemical methods.

The BPOUSC is in the process of completing an updated technology screening, building upon past work performed by Aerojet. This effort will include a literature review, a review of recent patents and technical articles, and a review of additional technical performance data which may have been generated by various parties interested in perchlorate treatability but not present in the literature.

3.2 Bench-Scale Laboratory Testing

Bench-scale treatability studies for several biochemical and chemical reduction treatment methods were performed by an Aerojet consultant in 1995. The tested water came from Aerojet's Sacramento facility and contained between 7,000 and 8,000 $\mu\text{g/L}$ perchlorate.

Relatively high dosages of several reducing agents (sodium sulfite, sodium bisulfite, and sodium thiosulfate) up to 1,000 mg/L were added under ambient conditions to water containing 7,000 $\mu\text{g/L}$ perchlorate. As perchlorate concentrations did not significantly decrease over time, these reducing agents were concluded to be ineffective, and the process was not taken to pilot-scale.

In addition to chemical reduction, Aerojet staff evaluated the use of ion exchange technology in more detail. Time was devoted to resin selection, resin regeneration, and treatment of regeneration wastes. Efforts were also made to develop a method for biodegradation of perchlorate in these wastes.

Two biochemical reduction methods were tested on a bench-scale: a fixed film bioreactor using submerged plastic media, and a fluidized bed bioreactor using a granular activated carbon media (GAC/FB). For both processes the water to be treated was amended with an organic carbon source (acetate or alcohol) and nutrients (nitrogen and phosphorus) before entering the bioreactor.

Both biochemical reduction methods were shown to be effective in reducing perchlorate concentrations. The GAC/FB system was more resilient, recovering more quickly from system upsets such as feed water variations. The GAC/FB system also accommodated a higher (6-fold) perchlorate loading rate of 0.70 grams perchlorate/liter/day in comparison to the submerged plastic media loading rate of 0.11 grams perchlorate/liter/day. Effluents for both processes were below the 400 $\mu\text{g/L}$ reporting limit for perchlorate.

Because of the success with the biochemical treatment methods, and due to the comparatively better performance of the GAC/FB method, this method was taken to pilot-scale.

3.3 Pilot-Scale Testing

In 1996, a 30 gpm skid-mounted pilot system, was set up at the Aerojet facility in Sacramento. The pilot-scale system operated between April and December of 1996. Operation of this pilot-scale system allowed optimization of feed rates for the organic carbon source (alcohol) and nutrients (nitrogen in the form of urea and phosphorus in the form of ammonium phosphate). Alcohol was added in molar ratio to perchlorate of approximately 4:1. Nitrogen and phosphorus levels were augmented to be similar to those described in the literature to assure microbial growth.

Effluent concentrations were consistently less than the 400 $\mu\text{g/L}$ laboratory reporting limit for perchlorate. Effluent concentrations were 500 $\mu\text{g/L}$ for phosphorus, 340 $\mu\text{g/L}$ for ammonia-nitrogen, and less than 50 $\mu\text{g/L}$ for nitrate-nitrogen.

The initial pilot-scale effluent contained very low or non-detectable levels of bacteria. After one month of operation, bacteria were at non-detectable levels.

3.4 Full-Scale Design

Aerojet is in the process of designing a full-scale perchlorate treatment system for one of the groundwater extraction and treatment systems at their Sacramento facility. The design and construction are currently scheduled to be complete in the fall of 1998. The hydraulic loading rate for the system is 1,500 gpm. The

full-scale system will be similar to that pilot-tested in 1996.

Aerojet is working with the design contractor to optimize certain design features which will result in lower effluent concentrations. The pilot-scale study was completed prior to the recent reduction in laboratory reporting limits by agency and commercial laboratories and, therefore, Aerojet and its contractor are hoping to modify either the design or operating parameters to produce effluent below the 18 $\mu\text{g/L}$ provisional action level.

In addition, Aerojet and its contractor have located an alternative source of microorganisms. Waste sludge from the food processing industry was determined to contain acceptable microorganisms.

3.5 Biological Treatment Technology Overview

Biological treatment, or biochemical reduction of perchlorate, involves a microbially induced reaction in which perchlorate is biochemically reduced to form chloride, oxygen, and biomass, simultaneous with the biochemical oxidation of an organic substrate. The substrate is typically selected based on its readily biodegradable chemical structure, non-hazardous nature from an environmental standpoint, relatively low cost, and availability.

Biological treatment technologies generally fall into two classes: suspended-growth and attached-growth (fixed-film). Attached-growth systems are expected to be better suited to the relatively low influent perchlorate concentrations and are therefore the focus of BPOUSC efforts. Attached-growth systems can typically attain higher concentrations of microorganisms per unit reactor volume, and because the microorganisms are attached to media within the biological reactor, there is no requirement for return of microorganisms to the treatment reactor.

The GAC/FB technology is an attached growth (fixed film) process which utilizes granular activated carbon as a support medium for biological attachment and growth in a fluidized bed reactor. The GAC/FB technology offers the additional advantage of greater surface area on which microorganisms can attach and grow, as

well as the presence of activated carbon, which provides some buffer capacity to varying operating conditions. Groundwater, amended with an organic substrate (e.g., alcohol, acetate) and nutrients (nitrogen and phosphorus), is introduced into the treatment bed. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, simultaneously bioreducing the perchlorate. Thus, the microorganisms multiply to a steady-state level, determined by the organic loading to the system.

Non-viable microorganisms eventually become detached from the media, and exit the system in the groundwater effluent, allowing new microorganisms to attach and reproduce. The reaction takes place under anoxic conditions, and therefore no air or oxygen (other than that contained in the influent water) is introduced to the system.

4.0 DATA REQUIREMENTS

The long-term goals of this treatability work are: 1) to demonstrate the technology can achieve effluent goals for perchlorate and nitrate concentrations, and 2) to collect the data necessary for the design and construction of a full-scale treatment unit that will be part of the BPOU treatment train, delivering potable water to local and regional water purveyors.

The objectives of this Phase 1 treatability study are to evaluate the performance of the GAC/FB treatment technology previously tested at Aerojet's Sacramento facility with the following modifications:

- Decrease the concentration of perchlorate in the influent to a concentration representative of that which will be present in San Gabriel Basin groundwater
- Increase the concentration of nitrate in the influent water to a concentration representative of San Gabriel Basin groundwater
- Achieve a lower perchlorate concentration in treatment plant effluent
- Test the effectiveness of an alternative source of microorganisms.

- Evaluate the characteristics of the effluent to ensure potability.

Phase 1 testing is planned at Aerojet's Sacramento facility because many of the pilot system components are onsite, staff familiar with prior pilot system construction and operation are available, and there are no complicating issues related to the discharge of treated water.

4.1 Demonstrate Technology Can Achieve 18 µg/L Limit or Lower

At the time the pilot-scale study was performed at Aerojet's Sacramento facility, the goal was to produce effluent that was less than the 400 µg/L laboratory reporting limit current at that time. When the pilot-scale study was completed, the effluent generally was characterized by perchlorate concentrations less than 100 µg/L. Measurement of concentrations at this level had a higher level of uncertainty as they were below the established reporting limit. At that time it was not possible to measure to the current reporting limit of 4 µg/L. Therefore, it was not possible to optimize system flow rate, organic carbon source, or nutrients to see if lower effluent concentrations were possible. Therefore, it is uncertain if the full-scale system to be constructed by Aerojet in Sacramento may reach treatment goals for the BPOU. Treatability studies will need to demonstrate that a sufficiently low perchlorate concentration in treatment plant effluent is possible.

4.2 Evaluate Lower Perchlorate Influent Concentration

Based on the distribution of perchlorate in San Gabriel Basin groundwater, the configuration of extraction wells and flow rates described in the December 1996 Pre-Remedial Design Report (CDM, 1996), and modifications to the extraction plan discussed with U.S. EPA, the BPOU extraction system, as conceived, would produce groundwater containing concentrations of perchlorate between 50 and 100 µg/L. This value was estimated by selecting surrogate wells for each extraction well location, assigning recently measured concentrations from each surrogate well to its corresponding extraction well, and flow-weighting these concentrations based on expected pumping rates to produce a flow-weighted average concentration for the BPOU

extraction system. This method is a rough estimation of concentrations that will be initially extracted. The actual concentrations present in the extracted groundwater will be known after extraction wells are constructed and pumped at their designed flow rate.

Although concentrations of perchlorate in groundwater at Aerojet's Sacramento facility that were used as influent to the pilot test ranged from 7,000 to 8,000 mg/L, there are wells at the Sacramento facility that have lower perchlorate concentrations. This treatability test will extract water from a well containing a perchlorate concentration representative of that anticipated in San Gabriel Basin. The selected well (40-11) is currently part of one of Aerojet's groundwater extraction and treatment systems (GET-B). This well consistently produces water containing approximately 50 µg/L perchlorate and 50 to 70 mg/L nitrate.

4.3 Utilize Higher Nitrate Influent Concentration

Pilot testing at Aerojet's Sacramento facility treated groundwater characterized by low (1.5 mg/L) nitrate concentrations. The results of the pilot-scale study performed in Sacramento show effluent nitrate concentrations less than 0.05 mg/L. This suggests that along with consumption of alcohol and reduction of perchlorate, that reduction of nitrate is also occurring in the fixed film bioreactor.

Supporting evidence that the same anoxic conditions that contribute to the reduction of perchlorate may also reduce nitrate concentrations may be found in the literature where processes using bacterial denitrification of wastewater have been described. Although denitrification has not been widely applied to drinking water systems, such systems do exist in Colorado, Texas, and France. One such system was designed for the town of Wiggins, Colorado to denitrify their drinking water. The process equipment, designed and testing performed by Joann Silverstein of the University of Colorado, Boulder (Silverstein, 1997). The system consists of a packed tower fixed film bioreactor where denitrifying bacteria are supported on a high-porosity plastic media.

This observation could have a significant beneficial effect on the BPOU project as influent nitrate concentrations have been estimated between 20 and 25 mg/L, by the same method described above to estimate influent perchlorate concentrations. Although these concentrations are well below the 45 mg/L MCL, they are substantially higher than concentrations currently received by customers of MWD and TVMWD. Should the GAC/FB biochemical system prove to be an effective method of reducing nitrate concentrations in treatment plant effluent, it may be possible to reduce both perchlorate and nitrate concentrations.

Preliminary evaluation of candidate wells identified a well (40-11) at Aerojet's Sacramento facility that has historically produced water containing between 50 and 70 mg/L nitrate. In addition, this well is part of a current groundwater extraction system (GET-B) so that water quality is anticipated to remain relatively constant for the duration of the pilot test.

4.4 Evaluate Different Source of Microorganisms

The source of microorganisms in the previous study was municipal wastewater treatment plant sludge. This approach presents a concern related to the introduction of pathogens into potable water supply. Pilot-scale work performed at Aerojet's Sacramento facility demonstrated that pathogens are not present in pilot plant effluent; however, the potential presence of these pathogens remains a concern.

The Phase 1 treatability study will utilize waste sludge from the food processing industry. The waste sludge will likely contain microorganisms appropriate for perchlorate reduction, but lack the pathogens that may be of concern.

4.5 Potability of Treated Water

For the BPOU project to be viable it must deliver potable water to local and regional water purveyors. Therefore the selected treatment train must produce water that meets all federal and state requirements for a potable water supply. Embodied in the objectives described above are the need to produce water that contains acceptable concentrations of perchlorate and nitrate and lacks pathogens. In addition this

pilot-scale testing will evaluate all other applicable water quality parameters to ensure treatment plant effluent can achieve other potable water quality goals.

The source water and the effluent will be tested for an appropriate range of water quality parameters including those specified in the Safe Drinking Water Act and the California Code of Regulations, Title 22.

4.6 Phase 2 Pilot-Scale Treatability Study

Assuming Phase 1 results demonstrate effluent goals can be met, Phase 2 testing would be performed. It is the intention of the BPOUSC to perform Phase 2 treatability testing at a site in the San Gabriel Basin. Details and logistics regarding this testing will be developed during the performance of Phase 1 testing. Details which will be resolved during Phase 1 testing will include the well site where treatability testing will be performed, the flow rate at which the testing will be performed, and the method and condition under which the effluent will be delivered.

Phase 2 testing could commence in early 1998, with testing complete and a draft report available for EPA review later in 1998. Adherence to this schedule is dependent upon several key assumptions. These include identification of a suitable site for testing, an agreement with the current well owner/operator, resolution regarding the flow rate to be tested, resolution regarding use of the water and disposal of wastewaters, and the ability to design and construct a Phase 2 system at the selected flow rate within this timeframe.

In late 1998 Aerojet's Sacramento perchlorate treatment unit should be on-line and several months of performance data should be available. Input from both phases of treatability testing and performance data from Aerojet's Sacramento treatment unit would allow the BPOUSC to proceed with design of the BPOU project.

Preliminary Phase 2 treatability testing objectives are to: 1) determine the efficiency of perchlorate reduction, 2) evaluate required nutrients, 3) assess factors affecting biomass stability, 4) assess the effect of various nitrate concentrations, 5) evaluate relative bacterial

preference for perchlorate and nitrate and the role that competing electron acceptors play in system performance and 6) establish filtration/disinfection requirements for potable water use.

5.0 TREATMENT EQUIPMENT DESCRIPTION

The Phase 1 treatment system includes an extraction well, an air stripper with vapor phase carbon air emission control, a bioreactor with granular activated carbon, a fluidization pump, a nutrient feed system, an alcohol feed system, a biological growth control system, a 500 gallon equalization tank, and assorted pumps, valves, sensors, and piping.

The extraction well (40-11) is currently connected to the GET-B treatment system. This connection will remain, but a valve will be inserted in the line to allow flow to be diverted from the GET-B system to the Phase 1 treatment system as needed. This will allow well 40-11 to continue operating at a constant flow rate as the Phase 1 system is operated in recycle mode and as the treatment system flow rate is increased to the maximum design rate for this treatability test.

The conceptual design of the BPOU project central treatment plant includes air stripping technology to remove VOCs from San Gabriel Basin groundwater. For purposes of this Phase 1 treatability test it has been assumed that perchlorate removal will occur following VOC removal. Therefore for Phase 1 treatability testing VOCs will first be removed with the use of a portable air stripper. This portable air stripper contains a 70 gallon reservoir in its base which with appropriate sensors will be operated to ensure constant flow to the bioreactor. VOC-free groundwater will then flow into the GAC/FB bioreactor.

Following completion of planned Phase 1 treatability testing consideration will be given to reversing the order of the air stripper and bioreactor. This configuration was not initially selected for testing as the biological treatment of VOCs in groundwater may result in the formation of vinyl chloride, a compound not effectively removed by vapor phase carbon, or the presence of recalcitrant VOCs in the treatment stream which may complicate the interpretation of the effectiveness of perchlorate and nitrate treatment.

An alcohol metering line, constructed of stainless steel tubing, will be connected to the bioreactor influent line. The alcohol will be added to the influent to provide a readily-degradable carbon source for the microorganisms. The alcohol will be purchased in 55-gallon drums. Because the alcohol is flammable, the drums will be stored in a fire-rated outdoor storage cabinet which contains an integral sump for spill control. The alcohol will be metered from the 55-gallon drum using a hazardous duty diaphragm metering pump which is UL-listed for use in Class I, Group D, Division I hazardous locations. Containment around the metering pump will be provided for spill control. The flow rate of the alcohol will be measured with a graduated cylinder and stopwatch.

The central reactor for the GAC/FB pilot system will be leased from a contractor. The bioreactor is 20 inches in diameter and 15 feet high. Additional components for the pilot system are available at Aerojet's Sacramento facility. The pilot system, rated for a once through flow rate of 30 gpm (113.6 liters/minute), is skid mounted.

A photograph of a generalized GAC/FB bioreactor is presented as Figure 5-1. A generalized process and instrumentation diagram (P&ID) is presented as Figure 5-2. These figures are not specific to this Phase 1 Pilot-scale test. The specific components and configuration of the treatability testing equipment to be used for Phase 1 treatability testing will differ from these figures to suit treatability test objectives.

The GAC/FB pilot unit is enclosed in a weather resistant container for protection from freezing during cold weather operation. The piping located outside of the reactor column will be insulated as appropriate. The purpose is to maintain a relatively constant water temperature in the GAC/FB reactor and prevent icing if the ambient temperature drops significantly. Previous pilot-scale testing was performed from April through December of 1996 and only minor changes (1 to 2 degrees) in temperature were observed.

Seven sample ports will provide for the collection of water quality samples and measurement of field parameters at key locations throughout the treatment system. These seven sample ports will be located as follows:

1. Air stripper inlet line
2. Air stripper effluent line
3. GAC/FB influent line after strainer, alcohol feed, nutrient feed, and recycle line
4. 25 percent of flow path in GAC/FB bioreactor
5. 50 percent of flow path in GAC/FB bioreactor
6. 75 percent of flow path in GAC/FB bioreactor
7. Effluent line from GAC/FB bioreactor

Samples will be collected from the 25 %, 50 %, and 75 % positions along the bioreactor flow path using individual 1/2 inch PVC tubing with screened ends which extend from the top of the bioreactor down to the appropriate horizon in the bioreactor. All three tubes will be connected through a common manifold with a three-way valve for ease of sample collection.

After the effluent exits the bioreactor, it will flow by gravity to a 500-gallon, polyethylene equalization tank equipped with level controls. From the equalization tank, the effluent will be discharged directly to the GET-B treatment system. The purpose of this equalization tank is to assure the pump moving water to the GET-B system receives a constant flow.

The equalization tank pump will be a centrifugal end-suction pump. Operation of the effluent equalization tank pump will be controlled by high-high, high, and low-level switches in the equalization tank. When the high-high level switch is activated a signal will be sent to the solenoid valve to close the influent line. The closed valve will eliminate flow to the bioreactor which will then operate in recycle mode to prevent spills. In addition, the high-high level switch will act as a fail-safe shutdown and signal the alcohol metering pump to turn off so that it no longer supplies alcohol to the influent line. When the high-level switch activates, the equalization tank centrifugal pump will be sent a signal to turn on, discharging the contents of the tank to the GET-B Treatment Pond. When the

low-level switch activates, the equalization tank pump will be signaled to turn off. A totalizer will be installed to measure the total water flow treated by the system.

Filtration of the treatment system effluent will not be necessary before discharge. Pilot-scale testing of filtration equipment may be necessary prior to full-scale system design, but this testing if needed will be performed as part of the Phase 2 Treatability Study.

6.0 PILOT SYSTEM OPERATION AND MAINTENANCE PLAN

6.1 System Start Up and Operation

Upon delivery of the GAC/FB bioreactor to the site, a general/mechanical contractor will perform the mechanical and electrical installation. During system construction, personnel from HLA and Aerojet will provide oversight. The system will be filled with water and hydraulically operated prior to adding carbon or microbial seed to the bioreactor to ensure proper, leak-free operation.

After leak and mechanical testing, the system will be drained and the GAC/FB reactor column will be filled with the recommended amount of granular activated carbon. The remaining free volume of the bioreactor will then be filled with process water and the microbial seed.

From this point forward system operation is separated into two periods. The first is the startup period where microorganism growth and attachment occurs and basic bioreactor operating conditions are established. The startup period is planned for 2 weeks. The second period is referred to as the performance monitoring period where system operating conditions are optimized and performance monitoring samples collected. The performance monitoring period is expected to last 6 weeks.

During the startup period the bioreactor will be operated in recycle mode for approximately one week to allow for growth and attachment of the microorganisms to the GAC. During recycle mode, groundwater will not be flowing through the system. Batch additions of alcohol, nutrients, and perchlorate will be added on a regular basis to support the microbial growth. As an option

the bioreactor may be started up in flow through mode.

After sufficient time is allowed for microorganism attachment (one week), groundwater containing perchlorate and nitrate will be introduced to the bioreactor. At this time, the alcohol and nutrient feed systems will be started. The flow of groundwater will be gradually increased to the design rate for the treatability test. Initial flow will be 5 to 10 gpm, but as measured parameters show the bioreactor has stabilized the flow rate will be incrementally increased to the 20 to 30 gpm range.

The flow rate and the dosage of alcohol will be adjusted during the startup period to establish a stable microbial population in the bioreactor. Nutrients will be dosed at a rate sufficient to satisfy microbial requirements.

To assist in establishing stable operating conditions during the second portion of the startup period a profile of reactor conditions will be obtained. Water samples will be collected from sample ports on the influent and effluent lines and at the 25, 50, and 75 percent points along the bioreactor flow path. The profile of selected parameters and concentrations of selected ions including perchlorate will be evaluated to examine perchlorate destruction. These data will also be used to vary the alcohol and hydraulic loading rates in a controlled, step-like manner until the target organic loading rate is established.

Targeted analytical parameters will be measured before and after each change in operating conditions. Although it is anticipated that the system will respond rapidly to changes in influent quality, nutrient feed, or alcohol feed, approximately 24 hours will be allowed to pass, samples collected and results interpreted before additional changes are made. Assuming one day turn-around for laboratory analysis this will mean that operating changes will be made no more frequently than every 48 hours. This will ensure reactor stabilization and allow a better understanding of how changes to reactor operation affect effluent quality. Should results from the initial startup period and measurement of field parameters suggest the reactor stabilized more rapidly, this protocol will be modified.

Once the microbial populations have been established and stable bioreactor operating conditions achieved (2 week startup period), the system will be operated in the performance monitoring mode (6 weeks). System operating conditions will be optimized to match the feed rate for alcohol with perchlorate and nitrate destruction. The goal is to maximize perchlorate and nitrate destruction and produce effluent free of detectable alcohol. Sample collection and analysis will be performed as described in Section 7.0.

Analytical reporting limits are below health based standards for potable water so production of effluent without detectable alcohol will satisfy water supply requirements.

HLA personnel will assume operation and maintenance responsibilities. Operation and maintenance activities and frequencies will be modified as necessary to ensure proper control and performance of the Phase 1 treatment system. A logbook will be maintained at the site for recording all operating activities and observations. The logbook will serve as a daily checklist to ensure that necessary maintenance, sampling, and observations are conducted.

6.2 Health and Safety Plan

A Site Health and Safety Plan, prepared by HLA, will govern the activities of all HLA workers at the site who are associated with this pilot-scale treatability study. This plan will be prepared after Work Plan approval but prior to system start up.

7.0 SAMPLING AND ANALYSIS PLAN

The sampling and analysis portion of the Phase 1 treatability study is divided into two phases: a system startup period and a performance monitoring period. - During the first week of the startup period the objective is to build and establish the necessary population of microorganisms. The monitoring of field parameters and sampling and analysis schedule for this period is designed to support this objective. Field parameters will be measured and reported at least once each day. Although water quality samples will be collected on a daily basis

these samples will be analyzed for the limited number of laboratory analytes necessary to ensure the microorganisms are receiving sufficient organic substrate and nutrients.

In addition, early in the first week one influent sample will be collected and analyzed to provide a complete characterization of the source water. This will allow for modification of the analytical schedule if appropriate. Samples of air stripper influent and effluent will be collected and analyzed for VOCs as the air stripper is brought on-line to ensure VOCs are removed from the influent to the bioreactor.

During the second week of the startup period, monitoring of field parameters and sampling will be sufficiently frequent to provide complete characterization of the process influent and effluent, collect data to allow for bioreactor profiling, and allow adjustments to operating conditions.

After steady-state operating conditions are reached, less frequent but regular performance monitoring will be conducted to monitor treatment process performance.

7.1 Field Data Collection

During the first week of system startup, frequent monitoring of field parameters will be performed to assure steady-state conditions while microorganism populations are increasing and stabilizing. The parameters to be measured in the field include flow rate, dissolved oxygen (DO), pH, oxidation-reduction potential (redox potential), and temperature.

Flow rates will be continuously monitored with in-line, correlated flow meters. Flow meter readings will be confirmed by monitoring the effluent volume that accumulates in the polyethylene tank. A reference line for tank volume versus fluid height is present on the outside of the tank. The flow from the alcohol metering pump will be measured using a graduated cylinder and a stopwatch.

The bioreactor influent and effluent DO will be monitored at least once each day with a field DO meter and field probe or equivalent in-line device. Each day the DO meter will be calibrated using the air calibration method. DO

measurements will be corrected for temperature and pressure.

A hand held pH meter or equivalent device will be used to measure and record pH at least once each day. The meter will be standardized to two reference buffer solutions prior to obtaining each pH measurements.

A hand held platinum electrode or equivalent device will be used to measure and record redox potential at least once each day.

The temperature of bioreactor influent and effluent will be measured at least once each day with a hand held mercury thermometer or equivalent device.

During the second half of the startup period and the performance monitoring period field parameters will be measured and recorded on at least a daily basis. Field parameters will be measured and recorded whenever a water quality sample is collected.

7.2 Sample Collection

Seven sample ports will provide for the collection of water quality samples and measurement of field parameters at key locations throughout the treatment system. These seven sample ports will be located as follows:

1. Air stripper inlet line
2. Air stripper effluent line
3. GAC/FB influent line after strainer, alcohol feed, nutrient feed, and recycle line
4. 25 percent of flow path in GAC/FB bioreactor
5. 50 percent of flow path in GAC/FB bioreactor
6. 75 percent of flow path in GAC/FB bioreactor
7. Effluent line from GAC/FB bioreactor

The sampling and analytical schedules for the startup period are presented in Tables 7-1 (week

1) and 7.2 (week 2). The sampling and analytical schedule for the performance monitoring period can be found as Table 7-3. These tables illustrate the location and frequency of sample collection as well as the compounds, ions, and parameters to be monitored.

Sample tubing will be connected to the GAC/FB bioreactor influent and effluent lines using labcock ball valves to reduce the velocity of the sample as it enters the sample bottles and thereby reduce turbulence. Tubing and valves on sample port lines will be opened and extensively flushed prior to sample collection to ensure collection of representative samples.

Samples collected from the pilot treatment system will be in the form of discrete grab samples. Grab samples provide better control than composite samples for monitoring the effects that changes in influent quality and reactor operating conditions have on reactor performance.

After collection, VOC samples in zero-headspace vials will be inverted and inspected for the presence of bubbles. All samples will be placed into coolers for same-day transportation to the analytical laboratory. Influent and effluent samples will be stored and transported on ice to preserve the samples and to prevent cross contamination of samples. Upon arrival at the laboratory, the samples will be stored at 4°C in walk-in coolers. Samples collected on Sunday or holidays will be stored in a refrigerator onsite, as the laboratory is not open that day. Samples will be delivered to the laboratory as soon as possible.

Sample container selection and sample preservation techniques will comply with U.S. EPA guidelines detailed in SW-846. Sample tags indicating sample location, date and time of sampling, and the initials of the individual who collected the sample will be attached to each sample. Each sample will be logged onto a chain-of-custody form. Copies of all chain-of-custody forms generated during the pilot study will be kept on file and available for review.

7.3 Analytical Testing

The project laboratory will perform analyses for volatile organic compounds (VOCs), ammonia-nitrogen, alkalinity, chloride, phosphate, BOD,

COD, total suspended solids, total dissolved solids, turbidity, perchlorate, chlorate, chlorite, hypochlorite, chloride, ammonia, nitrate, nitrite, sulfate, sulfide, alcohols, metals, and bacteriology. The purpose of this testing is to evaluate the effectiveness and mechanisms of perchlorate reduction. Analytical testing will be conducted using the U.S. EPA approved methods. Analytical method requirements are detailed in Table 7-4. Detection limits for all parameters are below health based water quality (drinking water) standards where such standards exist.

7.4 Quality Assurance Project Plan

HLA's Quality Assurance Management Plan (QAMP) assures that appropriate measures will be taken to assure project data quality objectives (DQOs) are achieved and data integrity is maintained. In addition to DQOs, HLA's QAMP addresses methods for sample collection and handling, sample custody, the type and frequency of quality control samples, laboratory quality control procedures, methods for data verification, reduction, management and interpretation, record keeping and corrective actions.

For field activities approximately five percent of all samples will be collected as splits (duplicates). Sample splits (duplicates) and blanks will be submitted to the project laboratory on a more frequent basis during the startup period when samples are collected more frequently. Trip blanks will be used where laboratory contamination is a concern. Field blanks will be used where field contamination is a concern. Quality control samples will be collected, but less frequently during the performance monitoring period. Sample splits (duplicates) will be submitted more frequently for analyses that are performed more frequently. Table 7-5 describes the type and frequency of field quality control samples. All samples will be appropriately labeled, packaged, and will be shipped to the project laboratory under chain of custody.

Analysis of samples by the project laboratory will be performed in conformance with laboratory QC procedures and QC procedures specified by each of the certified or approved analytical methods. Table 7-6 details laboratory quality control procedures and statistical analysis guidelines.

8.0 WASTE STREAM MANAGEMENT

Under approval of the Central Valley Regional Water Quality Control Board, system effluent will be discharged directly to the GET-B treatment system. At the conclusion of the study, TCLP testing will be conducted to verify the GAC does not exhibit the hazardous characteristics. After reviewing test results, the GAC will be disposed of in accordance with applicable laws and regulations.

9.0 IMPLEMENTATION TEAM AND COMMUNICATION PLAN

9.1 Implementation Team

Activities described here will be implemented by the team shown on Figure 9-1. Individuals responsible for the implementation of the activities in this Work Plan are: 1) appropriately qualified and licensed, 2) have considerable knowledge of a range of treatment technologies and experience designing and performing bench-scale and pilot-scale treatability tests, and 3) are experienced with the methods and procedures including those related to Health and Safety and Quality Assurance required to perform the proposed work.

This treatability study will be performed by a team of personnel from HLA and Aerojet under the direction of BPOUSC Co-chairpersons, Don Vanderkar and Steve Richtel.

9.2 Communication Plan

Communication during the implementation of this treatability work will be conducted in a manner to facilitate timely decision making and communication of work progress. Lines of communication are shown on Figure 9-1.

John Catts will serve as technical director for the work and be responsible for communicating work progress to the BPOUSC and U.S. EPA.

It is anticipated that work progress and results will be communicated via telephone conversations, meetings, written correspondence, and reports as described in Section 10.0.

10.0 SCHEDULE

This Work Plan was prepared within the schedule proposed by the BPOUSC in the document entitled "The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin" dated July 15, 1997 (HLA, 1997a) This Work Plan was first issued in draft form on August 26, 1997. The U.S. EPA issued comments and approved the Work Plan in a letter dated September 12, 1997. The BPOUSC issued a "Final Phase 1 Treatability Study Work Plan" on October 6, 1997. The U.S. EPA issued comments on this document in a letter dated October 16, 1997.

This "Revised Final Phase 1 Treatability Study Work Plan" incorporates changes and additions resulting from design and construction of the Phase 1 treatment system and also addresses U.S. EPA comments from both September 12, 1997 and October 16, 1997 letters.

Planning and preparation for Phase 1 treatability testing commenced in mid September 1997. Assembly of the pilot-scale bioreactor is presently in progress.

The BPOUSC will provide U.S. EPA with progress reports in the form of conference calls approximately 30 and 60 days following approval of this Work Plan. Assuming an U.S. EPA Work Plan approval date of September 12, 1997, teleconference progress reports will be held in mid-October and mid-November, 1997.

The BPOU will submit to U.S. EPA a written Phase 1 treatability testing progress report within 75 days of Work Plan approval. This progress report will contain preliminary Phase 1 results if available. In addition this progress report will contain either a Supplemental Work Plan for Phase 2 Treatability Testing or an explanation as to why additional Phase 1 testing is necessary before a Phase 2 Work Plan can be prepared, and a planned submittal date for a Phase 2 Work Plan. These recommendations may include additional testing with reversal of the air stripper and bioreactor if appropriate.

Regardless, this written progress report will serve as the basis for establishing the schedule for the balance of Phase 1 treatability testing. A schedule for Phase 1 treatability testing is

provided below with tentative completion dates for activities that will occur following the submittal of the written progress report on November 27, 1997.

Task Description	Duration from approval	Task Completion Date
Draft Phase 1 Work Plan	---	8/26/97
EPA, DHS, MWD Review	0 days	9/12/97
Progress Report (telephone)	30 days	10/12/97
Phase 1 Mobilization	45 days	10/27/97
Progress Report (telephone)	60 days	11/12/97
Written Progress Report	75 days	11/27/97
Phase 1 Testing	105 days	12/27/97
Draft Phase 1 Report	150 days	2/25/98
EPA, DHS, MWD Review	165 days	3/12/98
Final Phase 1 Report	180 days	3/25/98

HLA, 1997b. Final Addendum to Sampling and Analysis Plan, Pre-Remedial Design Groundwater Monitoring Program, Baldwin Park Operable Unit, San Gabriel Basin, October 1, 1997.

Kaczur et al., 1992. Process and apparatus for the removal of oxyhalide species from aqueous solutions. U.S. Patent 5,167,777.

Korenkov et al., 1976. Process for purification of industrial waste waters from perchlorates and chlorates. U.S. Patent 3,943,055.

Silverstein, J. and University of Colorado. *Biological denitrification of water*. Patent awarded 1997.

Yakevlev et al., 1973. Method for biochemical treatment of industrial wastewater. U.S. Patent 3,755,156.

11.0 REFERENCES

Attaway et al., 1994. Propellant wastewater treatment process. U.S. Patent 5,302,285.

CDM, 1996. Draft Baldwin Park Operable Unit, pre-remedial design groundwater monitoring program, pre-remedial design report, December.

Harradine et al., 1993. Oxidation chemistry of energetic materials in supercritical water. *Hazardous Waste and Hazardous Materials* 10, pp. 233-246.

HLA, 1997a. The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin, July 15, 1997.

TABLES

Table 7-1
Sampling and Analysis Plan
System Startup Period (Week 1)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	2/week	1/week					1/week	4
Alcohols			7/week				7/week	14
Perchlorate			7/week				7/week	14
Chlorate, Chlorite, Hypochlorite			1/week					1
Alkalinity (carbonate, bicarbonate)			1/week					1
Chloride			1/week					1
Total Phosphorus			1/week					1
Nitrogen, Ammonia			7/week				7/week	14
Nitrogen, Nitrate, Nitrite			7/week				7/week	14
Sulfate, sulfide			1/week					1
Metals ¹			1/week					1
Bacteriology ²			1/week				1/week	2
Total Dissolved Solids			1/week					1
Total Suspended Solids			1/week					1
Turbidity			1/week					1
Biochemical Oxygen Demand			1/week					1
Chemical Oxygen Demand			7/week				7/week	14

¹ Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese

² Total and fecal coliform and heterotrophic plate count

Table 7-2
Sampling and Analysis Plan
System Startup Period (Week 2)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	2/week	2/week					2/week	6
Alcohols			7/week	7/week	7/week	7/week	7/week	35
Perchlorate			7/week	7/week	7/week	7/week	7/week	35
Chlorate, Chlorite, Hypochlorite			7/week	7/week	7/week	7/week	7/week	35
Alkalinity (carbonate, bicarbonate)			2/week				2/week	4
Chloride			7/week	7/week	7/week	7/week	7/week	35
Total Phosphorus			7/week				7/week	14
Nitrogen, Ammonia			7/week	7/week	7/week	7/week	7/week	35
Nitrogen, Nitrate, Nitrite			7/week	7/week	7/week	7/week	7/week	35
Sulfate, sulfide			2/week				2/week	4
Metals ¹			2/week				2/week	4
Bacteriology ²			2/week				7/week	9
Total Dissolved Solids			2/week				2/week	4
Total Suspended Solids			2/week				2/week	4
Turbidity			2/week				2/week	4
Biochemical Oxygen Demand			2/week				2/week	4
Chemical Oxygen Demand			7/week	7/week	7/week	7/week	7/week	35

¹ Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese

² Total and fecal coliform and heterotrophic plate count

Table 7-3
Sampling and Analysis Plan
Performance Monitoring Period (Weeks 3 through 8)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	1/week	1/week					1/week	18
Alcohols			7/week	1/week	1/week	1/week	7/week	102
Perchlorate			7/week	1/week	1/week	1/week	7/week	102
Chlorate, Chlorite, Hypochlorite			1/week				1/week	12
Alkalinity (carbonate/bicarbonate)			1/week				1/week	12
Chloride			1/week				1/week	12
Total Phosphorus			1/week				1/week	12
Nitrogen, Ammonia			1/week				1/week	12
Nitrogen, Nitrate, Nitrite			7/week	1/week	1/week	1/week	7/week	102
Sulfate			1/week				1/week	12
Metals ¹			1/week				1/week	12
Bacteriology ²			1/week				1/week	12
Total Dissolved Solids			1/week				1/week	12
Total Suspended Solids			1/week				1/week	12
Turbidity			1/week				1/week	12
Biochemical Oxygen Demand			1/week				1/week	12
Chemical Oxygen Demand			1/week				1/week	12

¹ Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese

² Total and fecal coliform and heterotrophic plate count

**Table 7-4
Analytical Method Requirements**

Analytes	U.S. EPA Method	Preservative	Holding Time	Sample Container	Sample Volume	Method Detection Limit	Reporting Limit
Volatile Organic Compounds	8260	HCL-pH<2	14 days	40 ml VOA	3 x 40 mL	Varied	5 - 100 µg/L
Alcohols	8015	4°C	14 days	40 ml VOA	1 x 40 mL	Varied	100 mg/L
Perchlorate	300 (modified)	Cool 4°C	14 days	Poly	125 mL	2 ppb	5 ppb
Chlorate, Chlorite, Hypochlorite	300	4°C	14 days	Poly	100 mL	Still being determined	200,20,50 ppb
Alkalinity (carbonate/bicarbonate)	310.1	4°C	14 days	Poly	500 mL	---	5 mg/L ppm
Chloride	325.2	4°C	28 days	Poly	50 mL	0.72 ppb	1.0 mg/L ppm
Total Phosphorus	365.5	H ₂ SO ₄	28 days	Poly	100 mL	0.04 ppb	0.3 mg/L ppm
Nitrogen, Ammonia	350.1	H ₂ SO ₄	28 days	Poly	100 mL	0.027 ppb	0.1 mg/L ppm
Nitrogen, Nitrate, Nitrite	353.1	4°C	28 days	Poly	100 mL	0.0044 ppb	0.1 mg/L ppm
Sulfate, Sulfide	375.4	Cool 4°C	Sulfate - 28 days Sulfide - 7 days	Poly	100 mL	---	1.0 mg/L ppm
Metals ¹	6000/7000	HNO ₂ - pH<2	6 months	Poly	500 mL	Varied	Varied
Bacteriology ²	9200	Sodium Thiosulfate - 4°C	24 hours	Plastic	100 mL	Varied	Varied
Total Dissolved Solids	160.1	4°C	7 days	Poly	100 mL	---	10 mg/L ppm
Total Suspended Solids	160.2	4°C	7 days	Poly	500 mL	---	5 mg/L ppm
Turbidity	180.1	4°C	2 days	Poly	50 mL	---	1 NTU
Biochemical Oxygen Demand	405.1	4°C	2 days	1L Amber	1,000 mL	---	3.0 mg/L
Chemical Oxygen Demand	410.4	HNO ₂ - pH<2	28 days	Poly	50 mL	8.9 ppb	10 mg/L

¹ Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese

² Total and fecal coliform and heterotrophic plate count

**Table 7-5
Field Quality Control Sample Schedule
(Total Samples)**

		Week 1		Week 2		Week 3		
Analytes	U.S. EPA Method	Splits	Blanks	Splits	Blanks	Splits	Blanks	Total Samples
Volatile Organic Compounds	8260		2 (T)	1	1 (T)	2	3 (T)	9
Alcohols	8015	1		2	1 (T)	6	3 (T)	13
Perchlorate	300 (modified)	1		2	1 (F)	6	3 (F)	13
Chlorate, Chlorite, Hypochlorite	300			2		1		3
Alkalinity (carbonate/bicarbonate)	310.1			1		1		2
Chloride	325.2			2		1		3
Total Phosphorus	365.5			2		1		3
Nitrogen, Ammonia	350.1	1		2		1		4
Nitrogen, Nitrate, Nitrite	353.1	1		2		6		9
Sulfate, Sulfide	375.4			1		1		2
Metals ¹	6000/7000			1		1		2
Bacteriology ²	9200			2		3		5
Total Dissolved Solids	160.1			1		1		2
Total Suspended Solids	160.2			1		1		2
Turbidity	180.1			1		1		2
Biochemical Oxygen Demand	405.1			1		1		2
Chemical Oxygen Demand	410.4	1		2		1		3

T = Trip Blank F = Field Blank

¹ Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese

² Total and fecal coliform and heterotrophic plate count

**Table 7-6
Laboratory Quality Control Procedures**

Analytes	U.S. EPA Method	Initial Calibration	Continuing Calibration	Standard	Method Blank		Matrix Spike		Matrix Spike Duplication		Laboratory Control Sample	
					Control Limit	Minimum Frequency	Control Limit (%R)	Minimum Frequency	Control Limit (RFD)	Minimum Frequency	Control Limit (%R)	Minimum Frequency
Volatile Organic Compounds	8260	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	60-140	1 per 20 samples	±30	1 per 20 samples	60-140	1 per 20 samples
Alcohols	8015	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	50-150	1 per 20 samples	±30	1 per 20 samples	50-150	1 per 20 samples
Perchlorate	300 (modified)	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	70-130	1 per 20 samples	±20	1 per 20 samples	85-115	1 per 20 samples
Chlorate, Chlorite, Hypochlorite	300	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±30	1 per 20 samples	50-150	1 per 20 samples
Alkalinity (carbonate/bicarbonate)	310.1	6 points	Every 10 samples	---	<R.L.	1 per batch	---	---	---	---	---	---
Chloride	325.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±30	1 per 20 samples	60-140	1 per 20 samples
Total Phosphorus	365.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	60-140	1 per 20 samples
Nitrogen, Ammonia	350.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples
Nitrogen, Nitrate, Nitrite	353.3	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples

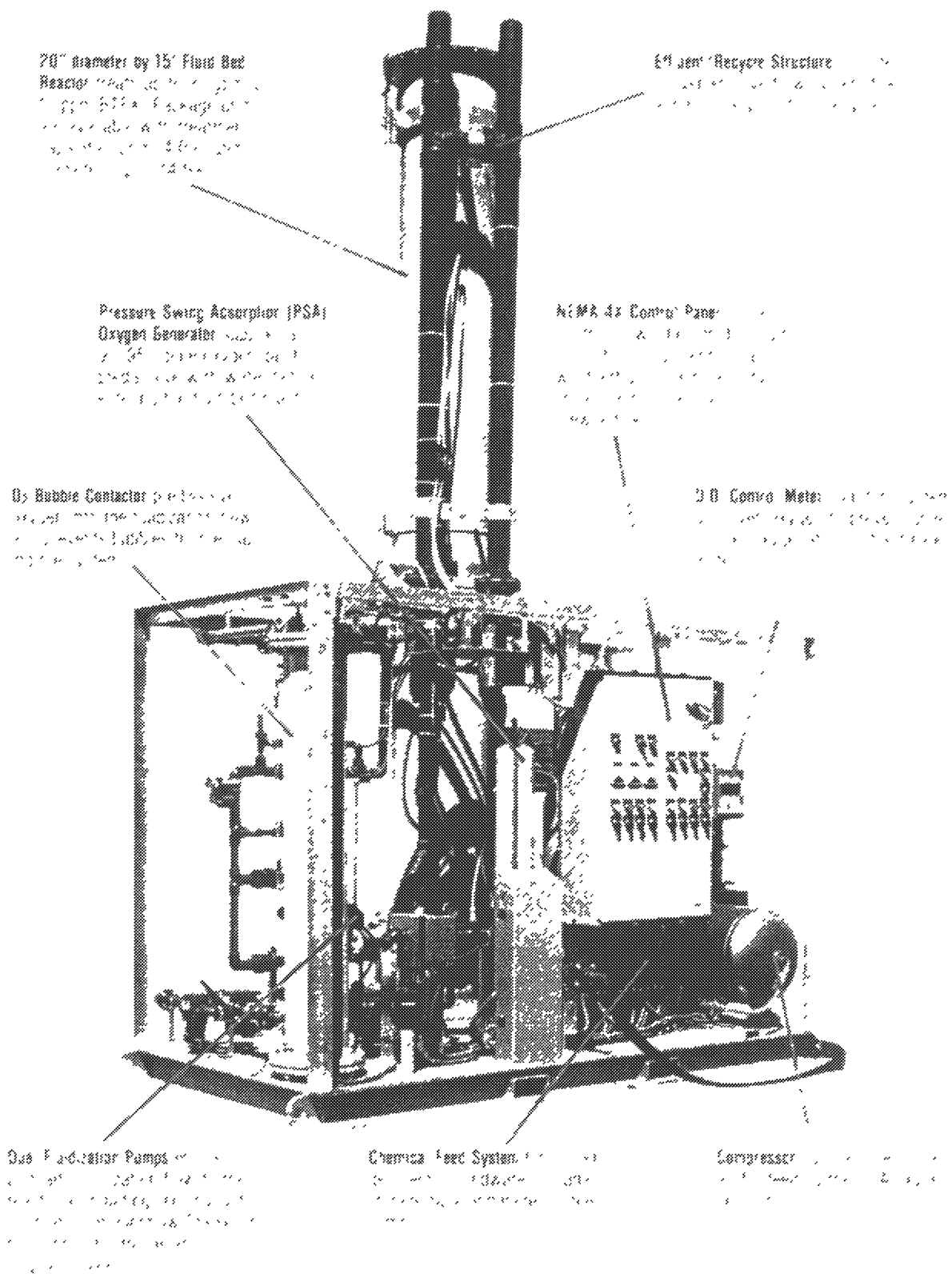
Analytes	U.S. EPA Method	Initial Calibration	Continuing Calibration	Standard	Method Blank		Matrix Spike		Matrix Spike Duplication		Laboratory Control Sample	
					Control Limit	Minimum Frequency	Control Limit (%R)	Minimum Frequency	Control Limit (RFD)	Minimum Frequency	Control Limit (%R)	Minimum Frequency
Sulfate	375.4	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples
Metals ¹	6000/7000	3 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	50-150	1 per 20 samples
Bacteriology ²	9221B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Dissolved Solids	160.1	---	---	---	<R.L.	1 per patch	---	---	---	---	---	---
Total Suspended Solids	160.2	---	---	---	<R.L.	1 per batch	---	---	---	---	---	---
Turbidity	180.1	---	---	---	---	---	---	---	---	---	---	---
Biochemical Oxygen Demand	405.1	N/A	N/A	N/A	<0.2	1 per batch	---	---	---	---	---	---
Chemical Oxygen Demand	410.4	6 points	Every 10 samples	Every 10 samples	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	---	1 per 20 samples

N/A = Not Applicable

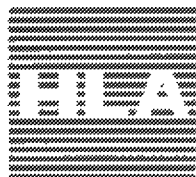
¹ Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese

² Total and fecal coliform and heterotrophic plate count

FIGURES



REFERENCE CONTRACTS-EQUIPMENT PROCUREMENT



Harding Lawson Associates
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Environmental Services

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Abstract

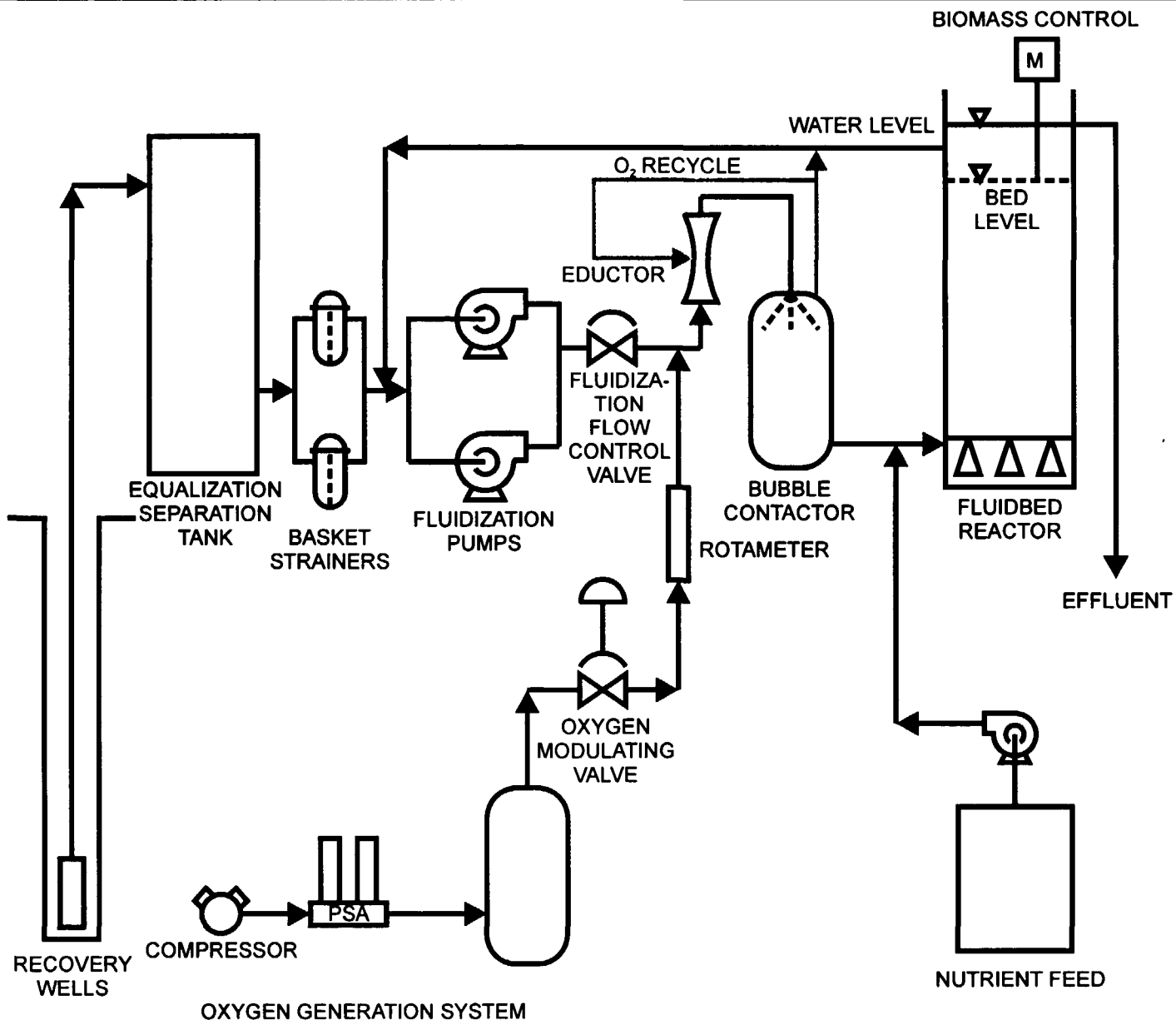
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5-1



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Environmental Services

DRAWN
JTL

PROJECT-TASK NUMBER
37933-003

**TYPICAL CONTRACTOR PROCESS AND
INSTRUMENTATION DIAGRAM**

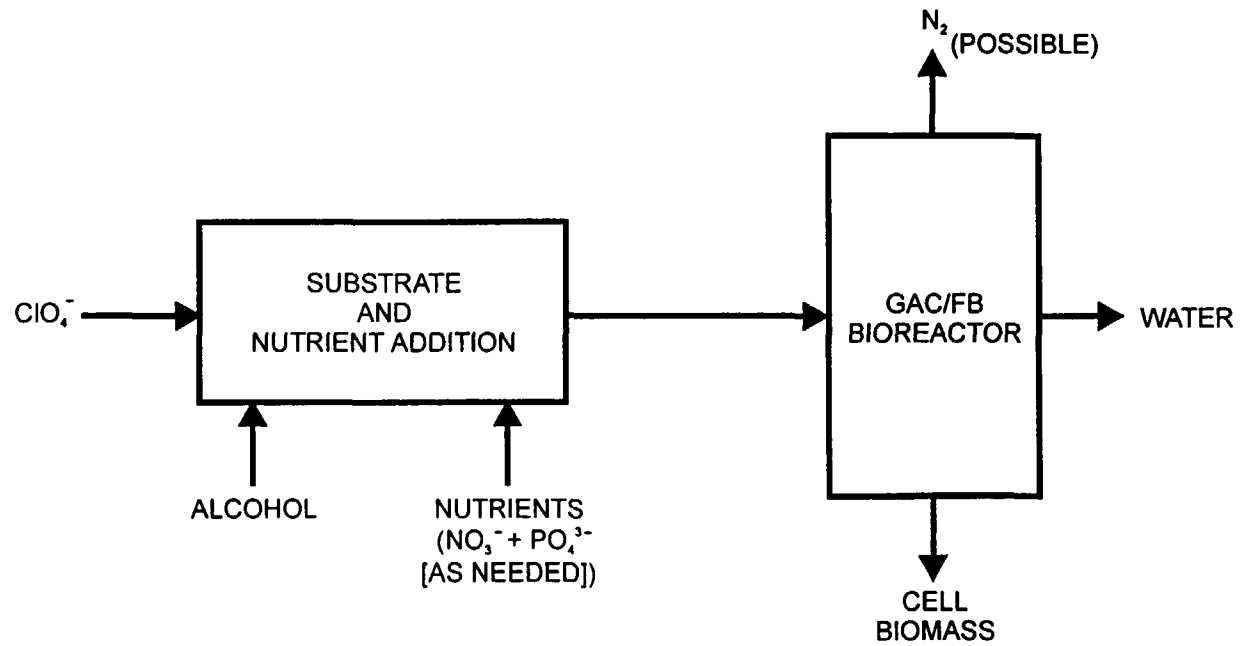
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DATE
8/97

REVISED DATE

FIGURE

5-2



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**IDEALIZED MASS FLOW DIAGRAM -
BIOCHEMICAL PERCHLORATE REDUCTION**

FIGURE

5-3

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PROJECT-TASK NUMBER
37933-003

APPROVED

DATE
8/97

REVISED DATE

Figure 9-1. Implementation Team

